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THE STANDING CROP OF BENTHIC ANIMALS IN A NORTH CAROLINA ESTUARINE AREA

RICHARD B. WILLIAMS AND LEON K. THOMAS
Bureau of Commercial Fisheries, Radiobiological Laboratory, Beaufort, N. C.

The Standing Crop of Benthic Animals in a North Carolina Estuarine Area

RICHARD B. WILLIAMS AND LEON K. THOMAS[1]

Bureau of Commercial Fisheries, Radiobiological Laboratory, Beaufort, N. C. 28516

Benthic organisms are an important part of the biota of shallow estuaries. Although only a few species may be of direct economic value, all form some part of the food web that ultimately sustains commercial fisheries, and are thus of concern in fishery investigations. Despite a long history of taxonomic and ecological investigations of marine benthic fauna of the Beaufort, N. C. area, only one study of standing crop has been made (Brett, 1963) and this limited to infauna containing hard parts likely to be fossilized. During August to November of 1963, benthic fauna were investigated at a single location in Beaufort Harbor to obtain some estimate of the standing crop. Although limited in scope, the study represents the only measurement of the biomass of benthos in a North Carolina estuary.

The area sampled, a gently sloping shore on the west side of Pivers Island, forms part of a shallow embayment about 3 ha. in extent. The embayment consists of mud flats, sand bars, and eel grass beds interspersed with channels up to 4 m. deep. The average tidal range is 0.9 m. During the period of sampling, salinity ranged from 27 to 36‰ and temperature ranged from 15° to 28° C., although the annual ranges in this area are at least from 13 to 36‰, and from 4° to 29° C. (Williams, 1966).

Methods

Ten samples of sediment were taken at each of five elevations. These elevations extended from 0.3 m. below mhw (mean high water) to 1.2 m. below mlw (mean low water) and included sediment types ranging from sand at the highest elevation through bare and eel-grass-covered muddy sand to soft ooze at the lowest elevation (Table I). Each sample consisted of five 71 cm.^{2} cores from 15 to 20 cm. deep. Cores were washed through a screen with openings 6 mm. square, and the organisms separated by hand from the material (mostly broken shell) that the screen retained. This screen retained all organisms weighing 0.2 g. or more, and an undetermined fraction of the smaller organisms. The smaller forms were entangled in the debris on the screen. Organisms were separated into taxonomic groups, counted, and weighed intact after blotting with paper. These live weights, which included inorganic material such as the calcareous portions of shells and the water trapped within body cavities, were multiplied by appropriate factors to convert them to weights of dry tissue. The factors (Table II) were obtained by drying representative species at 105° C. for ca. 24 hr. Prior to drying, mollusks, crustaceans, and echinoderms were decalcified by immersing them in 20% HCl until all hard parts were dissolved. Our factors are similar to those of Petersen (1918) and Petersen and Boysen-Jensen (1911).

Since the distribution of weights and numbers of organisms was highly skewed (with many small and few large values), the data were converted to logarithms (after adding one to each value to eliminate zeros) to help normalize the distribution. Estimates of statistical parameters were transformed back to the original units.

Results and Discussion

The five elevations differed by as much as two orders of magnitude in the average quantity of benthos retained by the 6 mm. screen (Table I). The (arithmetic) average weight and number were least at the highest and lowest elevations and greatest in the eel-grass-covered, sublittoral region (Elevation 4). At all elevations most of the total number and biomass were concentrated in one or a few samples. The individual sample with the greatest number of organisms contained 19 to 48 per cent of the total for its elevation, and the sample with the greatest live weight of organisms, 29 to 89 per cent of the total. Con-

[1] Present address: Coast Guard Division 13, APO San Francisco, Calif. 96291.

Table I

Standing crop of benthic animals adjacent to Pivers Island, Beaufort, N. C.

Elevation Number	Distance above mlw (m.)	Sediment	Range of values for 355-cm.^{2} Samples		Number (/m.^{2})			Live Weight (g./m.^{2})			Decalcified Dry Weight (g./m.^{2})		
			Number	Live Weight (g.)	Mean (Arithmetic)	Mean (Log)	Confidence Limits*	Mean (Arithmetic)	Mean (Log)	Confidence Limits*	Mean (Arithmetic)	Mean (Log)	Confidence Limits*
1	0.6	Sand	0-4	0-.64	28	19	3-45	2.6	.51	0-2.0	.28	.06	0-.25
2	0.3	Muddy sand	0-6	0-2.06	90	79	44-130	20	6.5	1.5-27	2.0	.79	.23-3.0
3	0.0	Muddy sand	2-9	<.01-17.48	124	111	75-162	56	2.9	.5-13	5.1	.45	.08-2.1
4	-0.6	Muddy sand with grass	3-115	<.01-40.82	672	371	158-825	294	47	7.6-280	32	5.0	.79-30
5	-1.2	Soft mud	0-6	0-3.48	48	35	11-73	13	3.1	.3-14	1.1	.25	.06-1.1
1 5					192			77			8.1		

*95% confidence limits for the mean of the logarithmic values.

Table II

Dry weight of benthic animals as a percentage of live weight

	Per cent
Crustacean*	
Barnacle	8%
Isopod	16
Decapod	20
Hermit crab (with shell)	5
Mollusk*	
Gastropod	10
Pelecypod	7
Echinoderm*	
Brittle star	10
Sea urchin	8
Tunicate	
Styela plicata	11
Annelid	20

*Decalcified prior to drying.

centrations of weight in individual samples came chiefly from one or a few large organisms, and not from an abundance of small organisms. At all elevations, 10 per cent or fewer of the animals composed over 50 per cent of both total live weight and total decalcified dry weight.

The statistical significance of differences among logarithmic means in Table I was determined by the method of Tukey (Snedecor, 1956, p. 251). The results are summarized below. The lines join elevations with means not significantly different at the 95 per cent confidence level.

	Number	Live weight	Dry weight
Elevation	1 5 2 3 4	1 3 5 2 4	1 5 3 2 4

Although animals were clearly most abundant in the eel grass at Elevation 4 (Table I), animal numbers at other elevations can be considered to form a continuum with no one average significantly different from all others. Differences between the logarithmic averages for both live and decalcified dry weight were significant only for the more widely separated values.

The taxonomic distribution of benthos by number and weight is summarized in Table III. In terms of total weight, the large tunicate, *Styela plicata*, which attached to clumps of eel grass, was the dominant organism, not only for Elevation 4 but for the entire area. *Styela* constituted 89 per cent of both the live and the dry weight at Elevation 4 and approximately 70 per cent of these weights for the entire 50 samples, but only 3 per cent of the population at Elevation 4 and 2 per cent of the entire population. Omitting *Styela*, the benthos were predominantly infauna, mainly mollusks and annelids. The annelids formed the majority of the population at all elevations, and the mollusks the bulk of the biomass at all elevations, except the fourth. Together they composed 90 to 100 per cent of the population, 78 to 100 per cent of the live weight, and 75 to 100 per cent of the decalcified dry weight. The remaining organisms were a variety of small crustaceans (crabs, amphipods, isopods, and barnacles) and two echinoderm species (a brittle star and a sea urchin). In addition to the groups listed in Table III, several others were observed in the samples from Elevation 4, but not enumerated. The eel grass and *Styela* had epiphytic growths of hydroids (mostly Sertularidae) and bryozoans, and there were great numbers of free-living nematodes a millimeter or two long.

Although the estimates of numbers of organisms per square meter (Table I) are very much smaller than most of those in the literature (Sanders, 1956, 1960, 1962), differences in methods preclude exact comparisons. Most of the small benthos passed through the 6-mm. screen, and since small forms normally comprise the majority of the population—e.g., 99 per cent in both Buzzards Bay, Mass. (Sanders, 1960) and Alamitos Bay, Calif. (Reish, 1959) —the actual population at Beaufort may be many times that recorded.

The mean value for biomass—8.1 g. dry tissue/m.^{2} (Table II)—may, on the other hand, approach the true value because the larger benthos form the bulk of the biomass (Holme, 1953; Reish, 1959; Sanders, 1960). This standing crop is similar to the 8.5 g./m.^{2} in Buzzards Bay and the 11.2 g./m.^{2} in the English Channel (Holme, 1953). The weight, 1.8 g. dry tissue/m.^{2}, of invertebrates with hard parts (mollusks, crustaceans, and echinoderms)—see Tables II and III—agrees with Brett's (1963) average value of 1.7 g./m.^{2} for inshore areas near Beaufort. The concentration of biomass in a few animals suggests that more precise measurement of total biomass will require adequate sampling of these relatively scarce large forms, as well as more complete sampling of the small forms.

Table III

Percentage distribution of benthic animals among different taxa

Animal	Number (%) at Each Elevation						Live Weight (%) at Each Elevation						Estimated Decalcified Dry Weight (%) at Each Elevation					
	1	2	3	4	5	1–5	1	2	3	4	5	1–5	1	2	3	4	5	1–5
Annelid[1]	70%	75%	86%	53%	59%	60%	7%	9%	3%	22%	9%	10%	12%	19%	7%	40%	20%	21%
Gastropod[2]	10	19	7	27	0	22	70	54	4	28	0	19	64	55	5	26	0	22
Pelecypod[3]	10	6	2	11	35	10	15	37	88	47	69	65	10	26	84	30	55	51
Crustacean[4]	10	0	5	6	0	5	8	0	5	2	0	3	14	0	4	4	0	3
Echinoderm[5]	0	0	0	<0.5	6	1	0	0	0	1	22	3	0	0	0	<0.5	25	3
Tunicate[6]	0	0	0	3	0	2	0	0	0	89*	0	68*	0	0	0	89*	0	72*

*Omitted in calculating the percentage distribution of the other animal groups.
[1]Species not identified. [2]*Bittium varium*, *Nassarius obsoletus*, *N. vibex*, and other species.
[3]*Atrina* sp., *Chione cancellata*, *Dosinia discus*, *Modiolus demissus*, *Pandora trilineata*, *Solemya velum*, *Tellina versicolor*, and other species. [4]*Balanus* sp., *Cilicea caudata*, *Pagurus longicarpus*, *Sphaeroma quadridentatum*, amphipods, and small crabs. [5]Sea urchin and brittle star. [6]*Styela plicata*.

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